



Evaluation of oxide catalysts' properties based on isopropyl alcohol conversion

Wincenty Turek*, Agnieszka Krowiak

Institute of Physical Chemistry and Technology of Polymers, Silesian University of Technology, Strzody 9, 44-100 Gliwice, Poland

ARTICLE INFO

Article history:

Received 8 July 2011

Received in revised form
12 December 2011

Accepted 16 December 2011

Available online 9 January 2012

Keywords:

Oxide catalysts

Test reaction

Acid–base properties

Redox properties

Isopropyl alcohol

Dehydration

Dehydrogenation

ABSTRACT

The aim of this work was to verify the usefulness of isopropyl alcohol conversion as a test reaction to evaluate the properties of the surface of oxide catalysts. The results presented below suggest that this test reaction can be used not only to distinguish the type of active centres over which the reaction proceeds but also to determine the strength of active centres. The strength of active centres can be evaluated on the basis of the rates of respective parallel reactions. The type of active centres can be determined from the rates of parallel reaction at the given temperature and selectivity of these reactions. The possibility of formation of diisopropyl ether over Lewis acid centres depends on the distance between the adjacent cations, their accessibility for reactants and the acidity.

© 2011 Elsevier B.V. All rights reserved.

1. Introduction

In studies on the properties of the surface of heterogeneous catalysts test reactions play an important role. A simple catalytic test, which does not require complicated equipment, can determine the properties of the catalyst surface under conditions of catalytic activity. It is known that an increase in temperature can change the number and strength of active centres [1,2], whilst most spectroscopic techniques show the properties of the surface at room temperature. Isopropyl alcohol conversion is the most popular amongst many proposed test reactions. Its wide application is due to the fact that this reaction can be used to determine both acid–base and redox properties of oxide catalysts [3–9]. Moreover, the reaction does not require complicated equipment and it is easy to carry out. During conversion of isopropyl alcohol three parallel reactions can proceed. The first reaction–dehydration to propene characterises acid [3–5] or acid–base properties of the catalyst [3,6]. The second reaction–dehydrogenation to acetone characterises basic properties [3–5,7,8] or redox properties of the catalyst [4,5]. The third reaction, which occurs rarely, is intermolecular dehydration of two alcohol molecules to diisopropyl ether. This reaction can characterise acidic properties of the surface [4,8].

Selectivity of these reactions is often used as a measure of acid–base and redox properties of the catalysts surface [3–9]. Some authors [7] write about acid–base properties of the catalyst when the reaction proceeds in an inert atmosphere and redox properties when the reaction proceeds in the presence of oxygen.

There are reports [3,7,10,11], which indicate certain problems or limitations associated with the application of this reaction to determine the properties of the surface of oxide catalysts. Correct interpretation of the results may be difficult as a result of:

- 1) the same reaction (dehydration or dehydrogenation) proceeding over various active sites [3,7], which is associated with changes in the mechanism of formation of a specific product;
- 2) various parallel reactions over the same active sites [3,7].

Therefore, the use of selectivity as an indicator of acidic and basic properties of the catalyst becomes doubtful. The selectivity depend not only on the nature of the catalyst, but also on the temperature [7,8,12,13]. Moreover, apart from three main reactions, there are several other possible consecutive and parallel-consecutive reactions in which the main products (propene and acetone) can be formed [7,10,12–15]. For example propene can be produced not only directly from isopropyl alcohol but also in a consecutive reaction from diisopropyl ether.

The objective of this work was to verify the problems associated with the use of isopropyl alcohol conversion to characterise the properties of the surface of oxide catalysts. An attempt was

* Corresponding author. Tel.: +48 322371417; fax: +48 322371925.

E-mail addresses: wincenty.turek@polsl.pl (W. Turek),
agnieszka.krowiak@polsl.pl (A. Krowiak).